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The Effect of Corporate Taxes on Firm Productivity in Korea*

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This paper explains how marginal corporate tax rate at the industry level affects individual firm productivity. I constructed the individual firm level data of over 1,000 firms in Korea from 1980 to 2010, and estimated an error correction model. Firm productivity was measured as total factor productivity, which denotes the residual of the estimated Cobb-Douglas production function. The results show that corporate taxes have a negative effect on firm productivity, and that the magnitude of productivity reduction from corporate taxes increases as the firm generates higher profitability. I also found that the total factor productivity of an individual firm increases faster in the sector which reveals faster growing productivity.

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1. INTRODUCTION

Over the last 40 years, Korean economy experienced remarkable growth. GDP per capita in 2010 reached to 20,540 USD from 1,688 USD in 1980.[1)] What made this change possible? Many economists argue that a tax regime is an important factor that influences economic growth (e.g., Kneller *et al*., 1999; Lee and Gordon, 2005; Romer and Romer, 2010). They found that a decrease in tax rate induces GDP to increase. Among many changes for the last four decades, consistent tax reforms in Korea have lowered the effective rate of corporate taxes.

What would be the linkage between corporate taxes and economic growth? Corporate taxes may affect economic growth through various channels. Corporate taxes influence resource allocating decisions of firms by distorting prices. The inefficiency would occur if a firm or industry does not use the optimal level of production factors as the response to corporate taxes. Consequently, it would impede economic growth in the aggregate level. Also, corporate taxes can affect the risk-taking behavior of entrepreneurs. High corporate taxes increase the price of risk-taking decision by reducing a firm's post-tax return. If firms avoid profit-enhancing but risky decisions and re-allocate inputs, their potential productivity growth may decrease. Finally, corporate taxes raise the user cost of capital. Higher user cost of capital prevents firms from investing in physical capital and R&D, impeding productivity improvement. In three potential channels, it is important to notice the role of productivity on economic growth.

However, there are a few studies on the relationship between corporate taxes and the productivity of individual firm. This paper analyses the effects of marginal corporate tax rate on total factor productivity of firms using individual firm level data in Korea.[2)] The statutory corporate tax rate

[1)] IMF World Economic Outlook Data (2012). The real values of 1,688 USD in 1980 and 20,540 USD in 2010 are 3,534 USD (year 2005) and 18,506 USD (year 2005) respectively. The economy has grown by 524% in real terms.

[2)] There are some studies that analyzed the change in total factor productivity in Korea. For example, Song *et al*. (2011) investigated the impact of government R&D expenditures on has consistently changed and tax favor programs vary across the sample period. Changes in corporate tax policy during the sample period lead to variation of the marginal tax rate. It allows us to identify the effect of corporate taxes from productivity changes over time. I derived the marginal corporate tax rate across industry in each year and included them as the variable for corporate taxes.

Total factor productivity accounts for the effects in total output not caused by change in inputs. So it measures the efficiency in the usage of production inputs, which is appropriate to capture the efficiency change of resource allocation from corporate taxes. In this paper, I assume a simple Cobb-Douglas production function with two factors which are capital and labor. Then the residual of the estimated production function is defined as total factor productivity. Production function is assumed to be different across industries.

The estimation method is based on a first-difference GMM. Assuming total factor productivity of a firm follows autoregressive distributed lag, I constructed an error correction model on growth of total factor productivity for each firm. The variables of main interest would be the lagged variable of a firm's own total factor productivity, the productivity gap with technological frontier firms in its sector, total factor productivity levels of technological frontier firms, and finally marginal corporate tax rates in its sector.

I found that corporate tax has a negative effect on total factor productivity of individual firms. In addition, total factor productivity grows faster in the industry where the marginal corporate tax is lower. To figure out if corporate tax affects firm's productivity through investment decision, I analyzed the relationship between the marginal corporate tax rate and the investment ratio. However, corporate tax has not affected the investment

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total factor productivity across 11 industries in Korea. They found the empirical evidences that government R&D expenditures raised total factor productivity in motor vehicles and parts, ship building and repairing, primary iron and steel products, electronic components and accessories, Semiconductors and related devices, and Display panel industries. This paper is different with Song *et al*. (2011) in two aspects. First, the main interest of this paper is to analyze the effect of marginal corporate taxes on total factor productivity. Secondly, total factor productivity is measured at firm-level.

ratio at the firm level.

The remainder of this paper is as follows. The next section reviews related literature, and then I provide the policy background of the corporate tax system in Korea. Section 3 describes the data. Section 4 explains the model and estimation results. Finally, section 5 summarizes the findings of this paper and concludes.

2. LITERATURES AND POLICY BACKGROUND

2.1. Literature Review

The effect of taxation on the economy has been one of the major interests in public policy. Some research on optimal taxation provides the linkage between taxes and productivity. Auerbach (1985) showed theoretical evidence that tax-induced distortion generates excess burden. Taxes make firms and households reallocate inputs, which induces deadweight loss. Inefficiency in resource allocation represents lower productivity. The empirical work estimated the welfare impact of taxation, and proved that deadweight loss exists. For example, Shoven (1976) estimated the welfare impact of corporate taxation using a simple deadweight loss formula. Some empirical studies tried to consider the responsiveness of taxable income to tax rates (e.g., Feldstein, 1995; Goolsbee, 2000). They showed that individuals decrease taxable income as tax rate increases, reducing productivity at the aggregate level.

Another linkage between taxes and productivity is the effect of taxes on risk-taking behaviors and investment. While theoretical and empirical research provides controversial results on how individual risk-taking decision responds to taxes, recent study suggested more strong evidence on the effect of taxes on entrepreneurship. Caroll *et al*. (2000, 2001) showed that investment and firm growth rate decrease as personal income tax rates are higher. Gemmell *et al*. (2010) estimated the effect of corporate taxes on industrial innovation. They found that firms in innovation intensive industries are more severely affected by high corporate tax rates.[3)]

While heaps of research has explored the linkage between taxes and productivity, there are surprisingly a few studies to estimate the effect of a single tax on productivity. Recently, some empirical literature began to tackle this issue as micro firm-level data became accessible. Vartia (2008) estimated the effect of corporate taxes on investment and productivity at the industry level, using the industrial data in OECD countries. The results show that the corporate tax burden decreases both investment and productivity within industry. Arnold and Schwellnus (2008) tested if the effect of corporate taxes depends on the industrial characteristics such as profitability, reassuring Vartia (2008)'s finding that higher corporate taxes are associated with lower total factor productivity. The result showed that total factor productivity grows faster in the industry with higher profitability when the corporate tax rate decreases. Since return on productivity-enhancing innovations goes down under a high corporate tax rate, high profitability sectors have less incentive to increase productivity.

This paper adds to these recent literatures to investigate the effect of corporate tax rates on firm productivity using micro-level data. Previous research focused on the cross-country analysis of well-developed countries. My interest is to find out if the negative relationship between corporate taxes and firm productivity still exists and how strong would it be in a fast-developing country. The effect of tax policy would vary across the level of economic development, so it would be important to narrow the scope down to a single developing country case. For this purpose, I will estimate the determinants of total factor productivity using the firm level data in a Korea from 1980 to 2010.[4)] It will also allow us to measure the effect of corporate taxes with less influence of the institutional difference across countries.

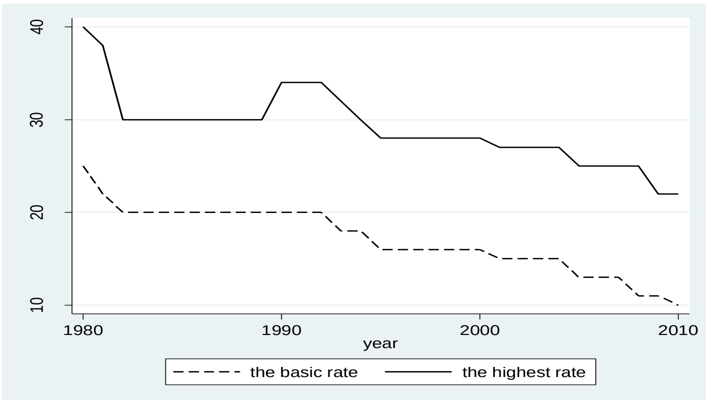
[3)] They used the measures such as research intensity, the extent of intra-industry trade and firm entry-exit rates to capture industries' innovative characteristics.

[4)] Korean economy has shown remarkable growth during this period. From 1980 to 2010, the nominal GDP increased by almost 24% and the average growth rate was 6.6%. Korea joined the OECD in 1996.

2.2. Policy Background

Corporate tax structure in Korea has consistently changed over the last thirty years. Tax reforms lowered the level of tax base intervals for the highest tax rate, and renewed categorization of corporation types. The most noticeable change is a decrease in tax rates. In 1980, the basic corporate tax rate for general corporations was 25% on the first 50 million KRW[5] of the tax base and 40% for the excess. In 1995, the basic corporate tax rate changed to 16% on the first 100 million KRW[6] of the tax base and 28% for the excess. These rates reduced by 6% points in 2010, which made the basic rate for the first 200 million KRW[7] of the tax base 10% and 22% for the excess tax base. Figure 1 illustrates the trend of the statutory corporate tax rates. Since 2000, the frequency of tax rate changes increased remarkably and the amount of tax rate reduction is relatively huge compared to the past. During the last ten years, corporate tax rate went down by 5% for both the basic rate and the highest rate. It is equivalent with the tax rate

Figure 1 Change in the Statutory Corporate Tax Rates in Korea



5) 50 million KRW (year 1985) is converted to 158,546 USD (year 2005).
6) 100 million KRW (year 1990) is converted to 209,176 USD (year 2005).
7) 200 million KRW (year 2010) is converted to 158,798 USD (year 2005). All conversions from the nominal value to the real value were made using IMF World Economic Outlook data (2012).

changes over twenty years from 1980 to 2000.[8)]

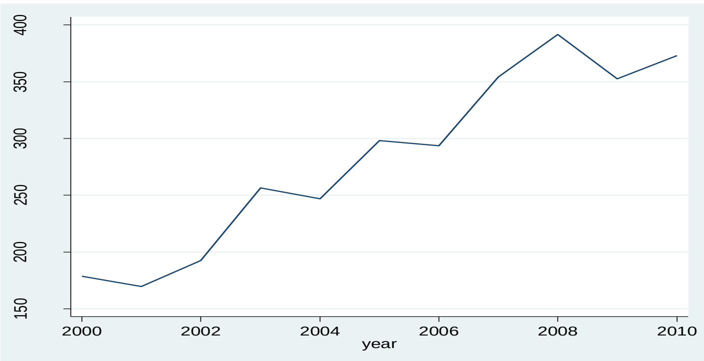
While corporate tax rates dropped rapidly over the last decade, corporate tax revenues were almost doubled. Table 1 shows annual corporate tax revenue in Korea from 2000 to 2009, and figure 2 illustrates its trend over the period. This is mainly due to expansion of the Korean economy. Tax revenue is likely to depend largely on business fluctuation. We cannot find any significant correlation between the statutory corporate tax rate and tax revenue. For measuring the effect of tax rates, we have to control year-specific characteristics.

Table 1 Corporate Tax Revenue in Korea

Year	2000	2001	2002	2003	2004
Tax Revenue (Growth Rate, %)	178,784	169,751 (–5.0)	192,431 (12.9)	256,327 (33.3)	246,783 (–3.5)
Year	2005	2006	2007	2008	2009
Tax Revenue (Growth Rate, %)	298,055 (20.6)	293,622 (–1.3)	354,173 (20.4)	391,545 (10.5)	352,514 (–9.7)

Source: Annual National Tax Statistics (2001-2011).
Note: Tax revenues are in current prices.

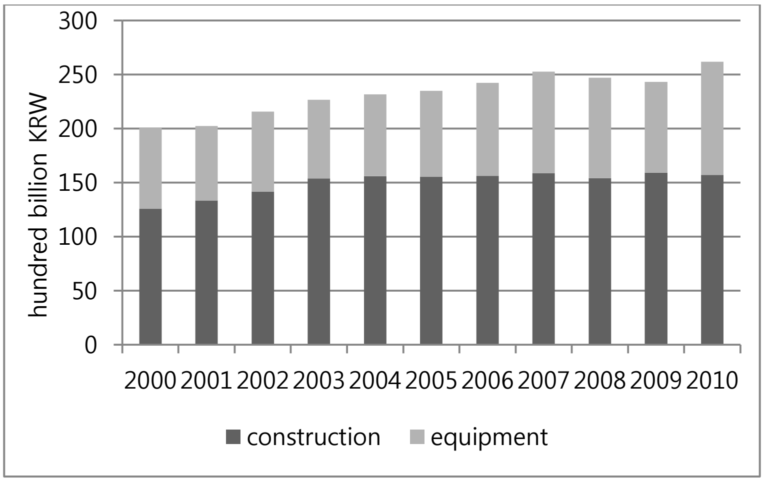
Figure 2 Trend of Corporate Tax Revenue in Korea



Source: Annual National Tax Statistics (2001-2011).
Note: Tax revenues are in current prices.

8) Besides changes in the statutory corporate tax rates, various tax policies affected the marginal corporate tax rates during the sample period. Since the statutory corporate taxes cannot capture the effect of tax exemption, tax deduction and tax expenditure programs, I will use the marginal corporate tax rates as explanatory variables.

Figure 3 Changes in Total Investment in Physical Capital



Source: Korean Statistical Information Service (2011).
Note: Total investments are in current prices.

Though the main interest of this paper is not investment decision, it will be meaningful to take a glance on the movements of aggregate investments given tax rate changes over time. Investment is considered as one of the most important factors that causes productivity growth.

Figure 3 illustrates total investments in physical capital at the national level. Fixed investment in physical capital is divided into construction investment and equipment investment. Physical investment had a negative growth in 2007 and 2008 when the global economic crisis began. But it recovered its upward pace again in 2010.

3. DATA

I constructed a panel data of listed firms in non-financial sector[9)] from the KIS-VALUE database.[10)] The sample period is between 1980 and 2010.

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9) There are 13 non-financial sectors.

10) KIS-VALUE database provides the comprehensive firm-level financial data of more than

Since the sample period is considerably long, not all firms exist during the whole sample period. So the data has the form of an unbalanced panel. The data is basically comprised of all the non-financial sectors, except some sectors that do not have a sufficient number of firms for estimation or in which public enterprises share a larger portion of the market than private firms.

The data has been cleaned for outliers. First, observations with negative values for wages, capital, value-added were eliminated from the sample. These variables must be greater than zero since they enter the production function. The production function with labor and capital will be estimated to derive the total factor productivity of each firm. Second, firms with a top 0.01 percentile and bottom 0.01 percentile of total factor productivity were removed from the data. So the final total factor productivity is defined as the residual from the second regression of the production function after eliminating these outliers. Third, the data contains only the observations with a positive investment ratio. An increase in total factor productivity is usually derived from capital accumulation or technological development which is directly related with investments. A negative investment ratio indicates that a firm liquidates its capital, which makes it difficult to observe the determinants of productivity increase.

For the last step, the firm that survives less than 7 years during the sample period was removed from the data. There are a few firms that exist during the whole sample period, which is not sufficient for estimation. Since certain periods of observation for each firm should exist for identification, the cut-off level of data continuation was determined as 7 years.[11)]

The final data contains 1,080 firms in 13 sectors. The number of total observations is 3,899. Table 2 summarizes the descriptive statistics of the variables.

21,000 firms in Korea. For details, visit http://www.kisvalue.com

[11)] Firms with age less than 6 years were excluded since behaviors of young firms tend to be different with others. Their investment decision and productivity change are more likely to be affected by other factors besides taxes.

Table 2 Descriptive Statistics

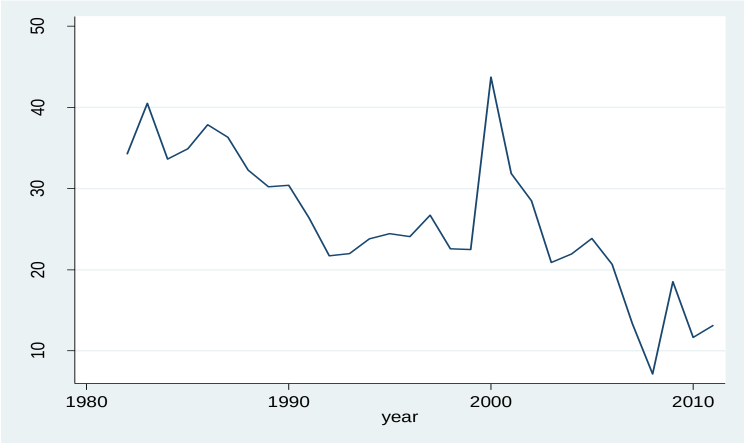
	Mean	Standard Deviation	Min.	Max.
Value-added (ten million KRW)	7,771.79	43,099.19	0.36	1,513,222
Labor (ten million KRW)	2,818.34	11,843.01	0.0005	333,258.6
Capital (ten million KRW)	17,030.33	97,698.31	0.032	3,440,792
Investment Ratio (%)	5.73	7.31	9.00e-06	79.61
Marginal Tax Rate (%)	27.42	13.32	–43.83	134.71
TFP Growth	–0.028	0.39	–5.36	4.31
TFP Growth of Technological Frontiers	0.03	0.26	–1.42	1.74
TFP Gap with Technological Frontiers	–0.87	0.53	–6.46	2.10
Asset (ten million KRW)	43,104.13	262,671.10	2.14	7,459,236
# of Workers	883.68	2872.71	8	60,898
Tobin's *q*-value	1.04	0.69	26.81	0.19

Value-added is measured as the sum of net profit before tax, total wages, depreciation, interest costs, rent, and total tax payment. Labor represents total wage paid to workers, and capital represents the net capital stock. The investment ratio is defined as the ratio of investment to the net capital stock. Investment is derived as change in net capital stock subtracting change in land assets. Land acquisition is not considered as investment since it can also have the purpose of asset accumulation. Nominal values are converted into real values using GDP deflator.

There are two traditional approaches to derive the marginal corporate tax rate. The first approach is measuring the sector-specific user cost of capital.[12] The user cost of capital means the unit cost for the use of a capital asset for one period — that is, the price for employing or obtaining

[12] See Jorgenson and Sullivan (1981).

Figure 4 Changes in Estimated Marginal Corporate Tax Rate



one unit of capital. It requires the exact calculation of asset price and depreciation which is difficult to obtain.

The second approach, which was adopted in this paper, derives the marginal increase of the tax burden for earning one additional unit of profit from the regression analysis. Corporate tax policies vary across industries and fiscal years. So I constructed industry-year subsample[13)] from the data and regressed the total corporate tax burden on net profit before tax in each subsample. Then the industry-year marginal corporate tax rate was defined as the estimated parameter of each regression. Figure 4 illustrates the average marginal tax rate of 13 industries over the sample period. The average marginal corporate tax rate has a decreasing trend with fluctuations except a noticeable peak in 2000. I conjecture that the introduction of deferred corporate tax system in 1999 generated some unexpected changes in the marginal corporate tax rate of the next year.

TFP growth at period t represents the difference in total factor productivity between period t and period t–1. Derivation of TFP growth for technological leaders at period t is similar. I define the technological leader group as the firms with the top 0.05 percentile of total factor productivity.

[13)] The data covers 13 industries and 31 years, so there are 403 subsamples.

TFP growth for technological leaders at period t denotes difference in TFP of the technological leader group at period t between period t and period t–1. Note that composition of the leader group can change over time. The TFP gap for firm i at period t is measured as the difference between the TFP of firm i and TFP of the technological leader group in i's sector. All the TFP-related observations are calculated at the individual firm level.

Asset, the number of workers and Tobin's q are the variables for estimating the investment equation. Tobin's q-value is approximated as the ratio of the market value in the stock market to the total value of debt for each firm.

4. MODEL AND ESTIMATION RESULTS

4.1. Model

To estimate the relationship between corporate tax and productivity, total factor productivity should be measured first. I use the residual from the estimation of a logarithmic Cobb-Douglas production function with capital and labor. The structure of the production function for firm i in sector s at period t is the following.

$$\ln Y_{ist} = \alpha_s + \beta_s \ln L_{ist} + \gamma_s \ln K_{ist} + \varepsilon_{ist}. \tag{1}$$

Y_{ist} represents a value-added of firm i in sector s at period t. L_{ist} and K_{ist} denote labor inputs and capital inputs as production factors. Labor inputs are measured as total wages, and capital inputs are measured as the net capital stock. Coefficients of production function were estimated for each sector, which allow us to avoid a strong assumption on homogeneity of production technology. Since marginal productivity of input factors may differ across sectors, we can derive a more realistic measure of total factor productivity from the sector-specific production function. Productivity estimates were obtained by estimating equation (1) using ordinary least squares.

Deriving the final measure of total factor productivity requires the following step. First, equation (1) is estimated using ordinary least squares with the industrial subset of the data and we obtain the estimates of α_s, β_s and γ_s. A_{ist}, the residual for firm *i* in sector *s* at period *t* is calculated using the equation (2).

$$\hat{A}_{ist} = \ln Y_{ist} - (\hat{\alpha}_s + \hat{\beta}_s \ln L_{ist} + \hat{\gamma}_s \ln K_{ist}). \tag{2}$$

Then I eliminated the observations of the firm whose A_{ist} belongs to either the top 0.01 percentile or bottom 0.1 percentile within the sector. Equations (1) and (2) are re-estimated with the updated dataset that cleans the productivity outliers. The measure of total factor productivity A_{ist} was obtained after finishing these steps for all the sectors in the data. Explanatory variables on productivity are based on these.

The estimation approach adopted in this paper follows Griffith *et al*. (2006) and Arnold and Schwellnus (2008). With the estimates of firm level total factor productivity, the main equation captures the effect of marginal corporate tax on total factor productivity. Now let us assume that total factor productivity of firm *i* in sector *s* at period *t* follows the Autoregressive Distributed Lag ADL(2,2) process. The underlying ADL model is:

$$\begin{aligned} A_{ist} = {} & \alpha_0 + \alpha_1 A_{ist-1} + \alpha_2 A_{ist-2} + \alpha_3 A_{fst} + \alpha_4 A_{fst-1} + \alpha_5 A_{fst-2} \\ & + \delta MTR_{st-1} + \tau_s + \tau_t + \varepsilon_{ist}. \end{aligned} \tag{3}$$

A_{ist} is a measure of total factor productivity for firm *i* in sector *s* at period *t*. It depends on the total factor productivity level of its own at period *t*–1 and *t*–2. A_{fst} represents the total factor productivity of technological frontier group in sector *s* at period *t*. A technological frontier group consists of the firms whose total factor productivity is in the top 5% percentile in each sector at each period. It indexes the frontier level of technological innovation and production efficiency in the sector. Similar to total factor productivity of each firm, the average total factor productivity of technological frontier group is assumed to be autoregressive with a two-period time lag. MTR_{st} denotes the marginal corporate tax rate in sector *s* at period *t*. It does not have subscript *i* since marginal tax rate was derived at the sector level. As seen in the equation (3), one period time lag variable of *MTR* is included in the equation. If corporate tax rates affect a firm's investment for productivity-enhancing innovations, productivity change will be realized with some time intervals.

Following Arnold and Schewellnus (2008), equation (3) can be converted into equation (4). It has the form of the error correction model, which allows us to interpret the meaning of estimated coefficients more easily.

$$\begin{aligned}\Delta A_{ist} &= \alpha_0 + \beta_1 \Delta A_{ist-1} + \beta_2 \Delta A_{fst} + \beta_3 \Delta A_{fst-1} + \gamma (A_{ft-2} - A_{ist-2}) \\ &\quad + \delta MTR_{st-1} + \tau_s + \tau_t + \varepsilon_{ist}.\end{aligned} \tag{4}$$

ΔA_{ist} denotes the growth in total factor productivity of firm *i* in sector *s* at period *t*, which was measured as the difference between A_{ist} and A_{ist-1}. TFP growth of firm *i* is determined by the TFP growth of technological frontier group ΔA_{fst}, as well as the TFP growth of its own in the past ΔA_{ist-1}. $(A_{ft-2} - A_{ist-2})$ is the term that represents total factor productivity gap between firm *i* and technological frontier group in *i*'s sector. It captures the convergence of total factor productivity across firms. The error correction model reflects the firm behavior in which the firm may make appropriate decisions on its productivity level to narrow down the productivity gap with the level it desires.

Equation (4) was estimated using the first-difference GMM method. I also provided the results from the two-difference GMM estimation for comparison. Note that firm *i*'s total factor productivity at period *t*–1 enters both the dependent variable and explanatory variable, which may induce an endogeneity problem. To solve the endogeneity problem, I used the instrument variables as the exogenous explanatory variables with high order lags. Two sets of instrument variables were used to check the robustness of the instruments. The first set of instruments includes all the explanatory variables from the second order lag. The second set consists of the explanatory variables from period t–2 to period t–4. I assume that the total factor productivity of technological frontiers is determined exogenously with that of the individual firm.

4.2. Estimation Results

The estimation results are reported in table 3. Column (1) and column (3) report the results from first-difference GMM, and the results from second-difference GMM are shown in column (2) and column (4). Instruments are the exogenous explanatory variables from the second order lag. We cannot observe any significant difference between the results from the two estimation method. Signs are all equivalent in two models, and magnitudes of estimated coefficients are also similar.

Our main interest is how corporate taxes affect firm's productivity. The estimated coefficients on tax rate are negative and statistically significant, implying that corporate taxes reduce total factor productivity at the firm level. One theoretical rationale for the negative relationship between corporate taxes and firm productivity would be distortive effect of taxes. Auerbach and Hines (2002) theoretically showed that taxes decrease the efficiency in the use of production inputs and thereby lower total factor productivity by distorting prices and input allocations within and between firms. This paper empirically supports their theoretical result. The estimated coefficients on the interaction term of tax rate and profit ratio[14)] show that this negative relationship is heterogeneous across firm characteristics. The results are provided in column (3) and column (4). Corporate taxes still have a significantly negative impact on total factor productivity. The magnitude of productivity reduction increases as the profit ratio of firm gets higher. The

[14)] The profit ratio is defined as the ratio of net profit before tax to total sales at the firm level.

Table 3 Estimation Results

	(1)	(2)	(3)	(4)
MTR (t–1)	–0.108* [0.063]	–0.092*** [0.013]		
MTR·profit Ratio (t–1)			–3.217*** [0.286]	–3.294*** [0.086]
TFP Growth of Frontiers (t)	0.285*** [0.034]	0.285*** [0.001]	0.283*** [0.034]	0.283*** [0.002]
TFP Growth of Frontiers (t–1)	0.510*** [0.043]	0.516*** [0.004]	0.450*** [0.045]	0.455*** [0.003]
TFP Growth (t–1)	–0.736*** [0.036]	–0.738*** [0.003]	–0.625*** [0.041]	–0.624*** [0.004]
TFP Gap (t–2)	0.782*** [0.044]	0.786*** [0.004]	0.682*** [0.048]	0.677*** [0.003]
Constant	–0.136 [0.112]	–0.083* [0.048]	0.445*** [0.128]	0.768 [0.494]
Observations	3,899	3,899	3,899	3,899
Number of Firms	1,080	1,080	1,080	1,080

Notes: 1) Standard errors in parenthesis. 2) *** p<0.01, ** p<0.05, * p<0.1. 3) The estimation in each column includes year dummy and industry dummy. 4) MTR (t–1) represents the marginal corporate tax rate at t–1 in firm i's industry. MTR·profit ratio (t–1) is an interactive term of the marginal corporate tax rate at t–1 in firm i's industry and firm i's profit ratio at t–1. TFP growth (t–1) denotes the difference of firm i's TFP at t–1 and TFP at t–2. TFP growth of frontiers (t) denotes the difference of technological frontier group's TFP at t and TFP at t–1 in firm i's industry. TFP gap (t–2) is the difference of technological frontier group's TFP at t–2 in firm i's industry and firm i's TFP at t–2.

firm with high profitability may have the capability to derive more return from the same amount of productivity-enhancing investment. If so, the additional tax burden from one unit's investment would be bigger for the firm with high profitability.

TFP growth of a firm is also affected by its industrial characteristics. TFP growth of the technological frontier group shows a positive coefficient. That is, TFP of an individual firm increases faster in the sector which reveals faster growing productivity. Note that the sector-specific effect was controlled by sector dummies. Technological frontiers seem to stimulate the other firms to enhance their productivity. And this stimulating effect of productivity frontiers exists regardless of the industrial characteristics. Even in the sector where productivity-enhancement is less important, technological frontiers induce productivity growth of the sector. As such, it has an important policy implication. The firms with high productivity growth rate have the leading role to shift upward the productivity level of the industry as a whole. Therefore, tax incentives or subsidy for productivity-enhancing investments should be designed to encourage them to achieve higher levels of productivity.

The estimation results on TFP growth at the previous period and TFP gap with technological frontiers provide the evidences for the existence of productivity convergence across firms. TFP growth at the previous period has a significantly negative effect on TFP growth at the current period. It implies that the growth of total factor productivity slows down if TFP increased faster in the previous period. If TFP of a firm persistently increases and the growth rate goes up over time, a convergence of the TFP level would be difficult to be realized. A negative coefficient on the past TFP growth represents that the marginal effect of productivity-enhancing innovations on productivity may decrease. In addition, a positive estimate on TFP gap shows that a bigger TFP gap with the technological frontier induces the firm to elevate its productivity faster. The level of total factor productivity will converge to the steady state if the firm with lower productivity level keeps growing fast.[15)] So, both results are consistent with convergence of TFP level across firms.

Since the estimation results may depend on the choice of instrument variables, I estimated equation (5) with another set of instruments which are the exogenous explanatory variable from period t–2 and t–4.

The results are reported in table 4. Column (1) and (3) use first-difference GMM, while column (2) and (4) are the estimates from second-

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[15)] The productivity convergence is observed between Asia-Pacific and Europe, not only within Korea. Krishnasamy and Ahmed (2009) showed that the gap between the Asian-Pacific group frontiers and the OECD frontiers is decreasing.

Table 4 Estimation Results: Robustness Check

	(1)	(2)	(3)	(4)
MTR (*t*–1)	-0.132^{***} [0.064]	-0.197^{***} [0.034]		
MTR·profit Ratio (*t*–1)			-3.294^{***} [0.086]	-3.012^{***} [0.274]
TFP Growth of Frontiers (*t*)	0.274^{***} [0.036]	0.284^{***} [0.013]	0.283^{***} [0.002]	0.279^{***} [0.012]
TFP Growth of Frontiers (*t*–1)	0.491^{***} [0.050]	0.521^{***} [0.018]	0.455^{***} [0.003]	0.452^{***} [0.018]
TFP Growth (*t*–1)	-0.710^{***} [0.046]	-0.725^{***} [0.017]	-0.604^{***} [0.052]	-0.618^{***} [0.019]
TFP Gap (*t*–2)	0.757^{***} [0.056]	0.777^{***} [0.021]	0.663^{***} [0.061]	0.674^{***} [0.023]
Constant	-0.084^{*} [0.117]	–0.007 [0.065]	0.768^{*} [0.049]	0.682 [0.516]
Observations	3,899	3,899	3,899	3,899
Number of Firms	1,080	1,080	1,080	1,080

Notes: 1) Standard errors in parenthesis. 2) *** $p<0.01$, ** $p<0.05$, * $p<0.1$. 3) The estimation in each column includes year dummy and industry dummy. 4) MTR (*t*–1) represents the marginal corporate tax rate at *t*–1 in firm *i*'s industry. MTR·profit ratio (*t*–1) is an interactive term of the marginal corporate tax rate at *t*–1 in firm *i*'s industry and firm *i*'s profit ratio at *t*–1. TFP growth (*t*–1) denotes the difference of firm *i*'s TFP at *t*–1 and TFP at *t*–2. TFP growth of frontiers (*t*) denotes the difference of technological frontier group's TFP at *t* and TFP at *t*–1 in firm *i*'s industry. TFP gap (*t*–2) is the difference of technological frontier group's TFP at *t*–2 in firm *i*'s industry and firm *i*'s TFP at *t*–2.

difference GMM. The signs and magnitudes are not different significantly with the results presented in table 3. I could obtain consistent results from other choices of instruments which are not presented here.

Previous results show that corporate taxes have an influence on total factor productivity, and that negative effects on productivity increases as a firm's profitability becomes higher. Then which channel do corporate taxes affect firm's productivity through? To answer this question, I estimated another equation relating to the firm investment and corporate taxes. Since the data on investment is available only on physical capital, I analyzed the relationship between physical capital accumulation and corporate taxes.

Firm level investment is determined by its financial status and future expectation. In this paper, the analysis follows the error correction model which was adopted by Kim (2005) who the considered the dynamic process of the investment. The estimating equation is constructed as:

$$\left(\frac{I}{K}\right)_{it} = \alpha + \beta_1\left(\frac{I}{K}\right)_{it-1} + \beta_2\left(\frac{CF}{K}\right)_{it} + \beta_3\left(\frac{CK}{K}\right)_{it-1} + \beta_4 SG_{it} + \beta_5 SG_{it-1} + \beta_5 SG_{it-1} + \beta_6\left(\frac{D}{K}\right)_{it} + + \beta_7\left(\frac{D}{K}\right)_{it-1} + \beta_8 MTR_{it-1} + y_t + \rho_i + \varepsilon_{it}. \tag{5}$$

The dependent variable is the investment ratio for firm i at period t. Gross investment I is measured as increases in the net capital stock except land. K denotes total asset. CF and SG represent cash flow and growth rate of sales respectively. D denotes total debt. All the variables were normalized as the asset, since the asset size can have an influence on firm's investment behavior.

Explanatory variables are investment ratio, cash flow ratio, growth rate of total sales, debt ratio, marginal corporate tax rate and their lagged values. A one-period lagged investment ratio enters the equation, which captures the persistence and dynamics of investments. Coefficients on cash flow ratio and debt ratio can show the effect of financial constraints. The growth rate of sales revenue enters to capture the effect of market expansion. The marginal corporate tax rate and year dummy are also included. A one-period lagged MTR is used to avoid endogeneity between tax rate and investment. There are two error terms, which represent time invariant error term ρ_i and time varying error term ε_{it}.

The investment decision at period t can affect the cash flow ratio or debt ratio at the same period. First-difference GMM was applied to this endogeneity. The estimation results are given in table 5. I used the data which contain observations whose investment ratio is lower than 0.3. The

Table 5 Estimation Results: Investment

	(1)	(2)	(3)
Investment Ratio (*t*–1)	0.099*** [0.011]	0.100*** [0.012]	0.076*** [0.016]
MTR (*t*–1)	0.015 [0.010]	0.014 [0.010]	–0.015 [0.011]
Cash Flow Ratio (*t*)	0.067** [0.033]	0.052 [0.034]	–0.043 [0.035]
Cash Flow Ratio (*t*–1)	0.094*** [0.028]	0.090*** [0.028]	0.053 [0.033]
Sales Growth Rate (*t*)	0.011*** [0.003]	0.009** [0.004]	0.017*** [0.004]
Sales Growth Rate (*t*–1)	0.001 [0.001]	0.0004 [0.001]	0.0003 [0.0009]
Debt Ratio at (*t*)	0.033* [0.018]	0.034* [0.018]	0.050*** [0.018]
Debt Ratio (*t*–1)	–0.056*** [0.017]	–0.056*** [0.017]	–0.068*** [0.017]
Asset		–0.002 [0.004]	–0.390*** [0.126]
Worker		0.091 [0.191]	0.272* [0.161]
Tobin *q* (*t*–1)			0.011*** [0.002]
Constant	0.012 [0.013]	0.014 [0.014]	0.008 [0.013]
Observations	8,097	7,996	4,296
Number of Firms	631	630	484

Notes: 1) Standard errors in parenthesis. 2) *** p<0.01, ** p <0.05, * p <0.1.

main results are given in column (1). Then I estimated two more equations. To control the firm size, I included two variables which are the value of asset and the number of workers. Also, the value of Tobin's *q* is included to test Tobin's *q*-theory. Tobin's *q*-theory suggests that firm's investment behavior is determined by Tobin's *q* which represents the ratio between the market value and replacement value of the same physical asset.

A marginal tax rate does not have a significant effect on investment ratio. Coefficient on marginal tax rate is even positive in column (1). Considering this analysis is limited to investment on physical capital, the marginal corporate tax rate is not a factor that a firm considers when making physical investment decisions. This result provides the indirect evidence that increase in physical investment is not a channel in which corporate taxes affect total factor productivity through, and consequently that efficiency improvement in resource allocation or risk-taking entrepreneurship play more important roles. The result does not change when we control the firm size in column (2).

Furthermore, the estimation result in column (3) shows how Tobin's *q*-value affected an individual firm's investment behavior. The estimation result is consistent with Tobin's *q*-theory. The firm with bigger Tobin's *q*-value has higher investment ratio. When Tobin's *q*-value is greater than 1, a firm finds additional investment profitable since the profits generated are higher than the cost of using the assets of the firm. However, the marginal corporate tax rate still has no significant impact on investment ratio after controlling Tobin's *q*-value.

The estimation results show that the investment ratio was rather affected by the firm's financial status and the dynamics of the investment process. The investment ratio has high persistence over time. A high cash flow ratio leads a high investment ratio, while a high debt ratio discourages a firm to invest. Sufficient cash flow can be used as resources for investment, but a high debt ratio is likely to work as a financial constraint when raising funds from the financial market. Sales growth rate also has a positive influence on investment ratio. Fast growing sales may represent that the market is expanding or the firm is increasing its market share. This will induce a firm to invest more in order to require change in market demand.

There are a few empirical studies on the relationship with corporate taxes and TFP at the micro-level and most of them utilize cross-country data. So we don't have sufficient cases for making comparison across various countries yet. However, it is possible to compare the empirical findings of this paper with the case of OECD countries. Vartia (2008) and Arnold and Schwellnus (2008) examined the effect of corporate taxes on total factor productivity in OECD countries and European OECD countries respectively. They found that high corporate tax rate impeded the growth of total factor productivity.

The difference with this paper is that corporate taxes were turned out to decrease investments both in European OECD countries and non-European OECD countries according to Arnold and Schwellnus (2008). A negative relationship between corporate taxes and firm investment can be found in other countries such as Canada[16)] and the United States.[17)] However, in Korea, it has been a controversial issue. Some studies including Kim *et al*. (2003) argued that corporate taxes had a negative impact on firm investment in Korea, while Lee and Kim (2004) and Kim (2005) showed that there existed no significant relationship between corporate taxes and investment and that the effect was ignorable even if it existed. This paper reassures the specific case of Korea unlike other developed countries.

5. CONCLUSION

This paper analyzed the dynamic panel data of over 1,000 firms in Korea to investigate the effect of corporate taxes on firm productivity. The estimation provides the empirical evidence that corporate taxes have a negative impact on total factor productivity at the firm level. Marginal corporate tax rates decrease a firm's total factor productivity and these negative effects are estimated to be more severe on the firm with relatively high profitability.

I also found two important factors on productivity changes over time. First, the TFP of an individual firm increases faster in the sector which reveals faster growing productivity. The firms with high productivity

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[16)] Schaller (2006).
[17)] Cummins *et al*. (1996), House and Shapiro (2008).

growth rates have the leading role to shift upward the productivity level of the industry. Secondly, a bigger TFP gap with the technological frontier induces the firm to elevate its productivity faster. It proves that there exists convergence of total factor productivity across firms.

There has been a long debate about corporate taxes among policy makers, and change in corporate taxes was sometimes used as a political agenda. But considering that corporate taxes affect the economy through various channels, the effect of corporate taxes should be discussed in a broader range. In particular, total factor productivity is a key factor of sustainable growth in the long-run. And the role of the sector which creates more value added becomes more important for economic growth. This paper contributes to tax policy decision by expanding the view for corporate taxes to productivity.

The remaining question is to discover the mechanism which determines how corporate taxes affect firm productivity. This paper analyzed the effect of corporate taxes on physical investment to test the possibility that physical investment may be the link. But physical investment was not significantly related with corporate taxes. Answering this question is remained as a further study.

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